Quantifying Variation 6mins

Sunday, 25 October 2015 7:03 PM

- Allele, genotypic or phenotypic frequency

Allele Frequency
F(Allele) = (# of Homozygotes for the allele x 2 + # of Heterozygotes for the allele) /Total number of alleles
$\sum$ F(Allele) = 1

Broad Sense
- Denoted by H^2
- Inclusion of all potential sources of genetic variation such as dominance, epistasis, maternal and paternal effects
- $H^2 = V_{genotype}/V_{phenotypic}$

Narrow Sense
- Denoted by h^2
- Proportion of total phenotypic variation that is due to the additive effects of genes
- $h^2 = V_{additive}/V_{phenotypic}$

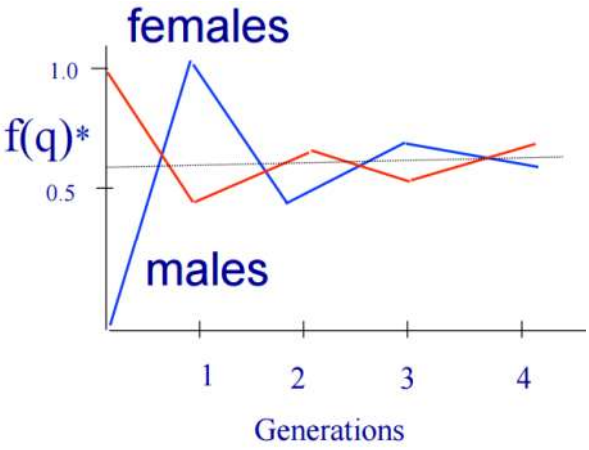
Hardy Weinberg Equilibrium
- HW means constant genotypic frequency due to constant allele frequency
- HW is a calculation of expected genotypic frequencies
- $P^2 + 2pq + q^2 = 1$
    - P and q are allele frequencies
    - P^2 = f(AA)
    - 2pq = f(Aa)
    - Q^2 = f(aa)
- Dominance does not mean increasing frequency
- Constant genotypic frequency does not mean HW but HW means constant genotypic frequency
- Assumptions:
    - Random Mating
    - No Selection
    - No Migration or gene flow
    - No Mutation
    - Infinite population: large enough to prevent sampling errors and random effects
- One round of HW does not bring back HW equilibrium
- Populations that are not evolving have genotypic frequencies that do not change across generations

X^2 - Chi Square
- $X^2 = \sum (O-E)^2/E$
- H_0: Observed difference/error is due to chance
- $p<0.05$ then we reject H_0

Heterozygote Undetermined with Complete Dominance
- Allele frequency of the recessive allele is the square root of the corresponding phenotype assuming HW
- Q^2 = f(aa)
- f(a) = $\sqrt{q^2}$
- Less accurate method
- Homozygote and heterozygote's must be distinguishable

X-Linked

- Allele frequency is the frequency of the trait in males
- If HW the allele frequency is also the same in females
- Cannot restore HW after nonHW in one round of HW as It takes multiple HW generations



Selection

- Fitness measure: Proportion of mature fertile offspring left by an individual
- Relative fitness (w)
  - 0 if no offspring is left or if they are infertile
  - 1 for genotype that leaves the most offspring
- Selection coefficient (s)
  - W = 1-s
  - S = 1, animal is dead or there is no offspring

$F(G_1) = f(G_0)w$/proportion of offspring going onto G1

G_0 - HbA = 0.8 HbS = 0.2 (allele frequency)

Assume H-W at G_0 →	(G_0)	Relative fitness	(G_1)	Genotypic Frequency in G1
f(HbAHbA)	0.64 $p^2 = (0.8 \times 0.8)$	1	0.64 X 1 = 0.64 0.96	0.67
f(HbAHbS)	0.32 $2pq = 2 \times 0.8 \times 0.2$	1	0.32 X 1 = 0.32 0.96	0.33
f(HbSHbS)	0.04 $q^2 = 0.2 \times 0.2$	0	0.04 X 0 = 0	

0.96 = 0.64 + 0.32 the proportion going on to next generation

$F(A) = [F(G_1)_{homozygote} \times 2 + F(G_1)_{heterozygote}] / 2$

Selective Agents

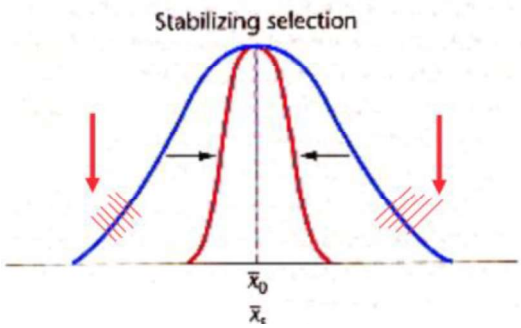
- Climate
- Pollution
- Predators
- Disease
- Insecticide
- Antibiotics

Stable Polymorphism

- Heterozygote form is the fittest
- Eg. Sickle cell in locations with malaria
- Equilibrium due to selection not HW

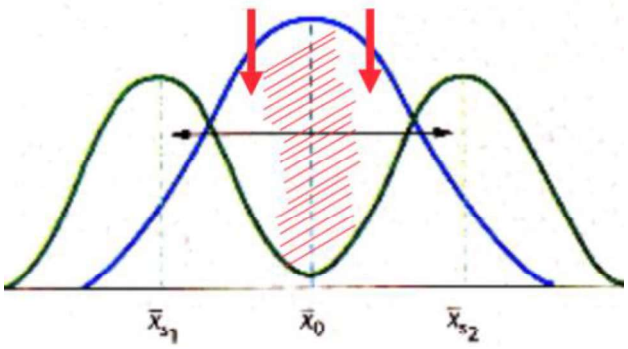
Stabilisation selection

- Selection against extremes in phenotype



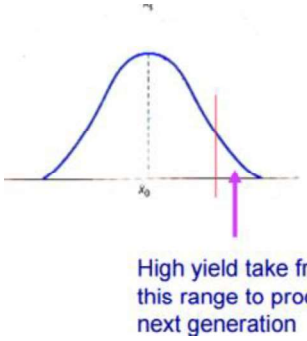
Disruptive Selection

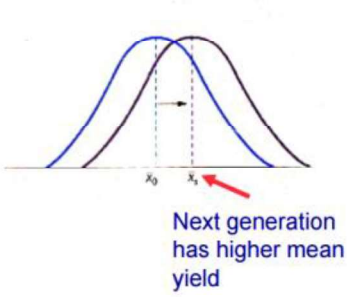
- Selection against the intermediate, often common phenotypes



Directional Selection

- Selection for one phenotype from the end of the phenotype and presumably genotype range
- Artificial selection is usually directional selection





Mutation

- On its own it has a minor change to allele frequency
- Source of all new alleles
- Can have a significant effect on allele frequency if selection also occurs

Migration

- $\Delta p = m(x-p)$
    - Δp = change in p, f(a) in one generation
    - M = migration rate, proportion of migrant genes entering resident population per generation
- 1-m= proportion of resident genes after one generation
- X = f(A) of migrants
- P = f(A) of residents
- $f(A)_{total} = p(1-m)+mx$
- If allele frequency is the same, p=x then migration has no effect

Non-random Mating
- Genetic relation: Mating between related individuals such as inbreeding, consanguinity, self fertilisation
- Assortative Mating (AM): Not genetically related
    - Positive Assortative Mating:
        - Select mates with similar traits
        - Humans do this
    - Negative Assortative Mating:
        - Select mates with opposite/different traits
        - Increase heterozygosity sometimes if phenotype has a genetic cause
- One individual contributes to a large number of offspring

Self-fertilisation
- Allele frequency the same
- Eventually only homozygote genotypes remain which changes the genotypic frequency

Consanguinity
- Alters genotypic ratios by increasing homozygotes
- Allele frequency remains the same

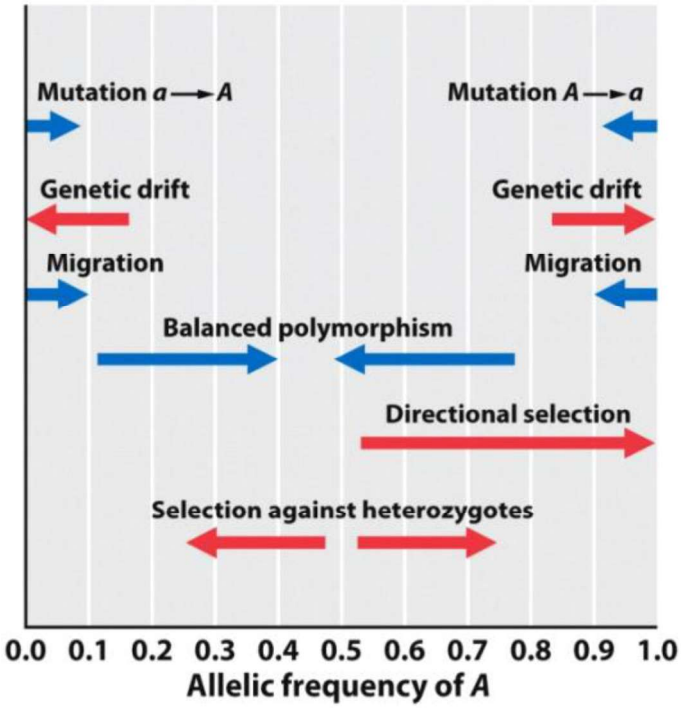
Relations
- 1st Cousin once removed: A parents cousin
- 2nd Cousin: Same great-grandparents
- Double 1st Cousin: Offspring of two different 1st Cousins

Population Size
- Population size needs to be large enough so change is not significant nor changes the allele or genotypic frequency.

Genetic Drift
- Random change in allele frequency due to sampling error
- Occurs in all populations but effect pronounced in small populations
- Founder effect: Small group left larger group with an allele which increases frequency within that group
- Bottleneck: Population goes through a severe reduction and only a few survive and reproduce

Modern Synthetic Theory of Evolution
1. Genetic Variability
    a. Gene mutation
    b. Change in chromosome
    c. Structure and number
    d. Genetic recombination
    e. Gene flow
2. Phenotypic Variation
3. Allele frequency different between populations
    a. Evolutionary Forces
4. Speciation

a. Reproductive isolation



Species

- Members of a species share a common gene pool

Speciation

- Separation of a gene pool
- Forces pushing allele frequency apart if greater than the forces keeping the allele frequencies the same
- Allopathic: Physical barrier splitting populations
- Parapatric: Similar to allopathic but occurs in adjacent regions
- Sympathic: Separation of gene pool within same area
    - Eg. Chromosome number imbalance

Polyploidy

- Organisms have more than two sets of chromosomes which is common in plants
- AA and BB form a AB hybrid which is sterile

Population isolation

- Habitat/geological/Ecological: Occupy different habitats
- Seasonal/temporal: Different timing of reproduction
- Ethological: Behaviour, often a ritual before mating
- Mechanical: Physically unable to fertilise possible due to pollinator restrictions
- Physiological: Gametes make it to female but do not survive
    - Only certain pollen form a pollen tube
    - Spermicide in vagina
- Gametic isolation: Inviability of male gametes in female reproductive tract

Post-zygote mechanism

- Fertilisation occurs and a hybrid zygote is formed

1. Hybrid inviability or breakdown: Dies after birth
2. Development of hybrid sterility
3. F2 breakdown

Inclusive fitness

- Helping others reproduce as they share similar genes
    - Ie. they are related

- Eg. Male dolphins

Hybrid Zone

- Region where two species overlap and produce hybrids